PUTTING RESEARCH TO WORK

BRIEF

Do Aggregate Characteristics Correlate with Base Course Strength?

The Wisconsin Department of Transportation uses 10 million tons of crushed aggregate each year as a base course layer in paving projects. The base course supports pavement surfaces, insulates them from frost, carries traffic loads and provides stable working platforms for road building. Wisconsin crushed aggregate base course materials are taken from a variety of stone quarries and sand and gravel pits, and these sites differ in geologic history. Aggregate from a pit on the west border of the state has likely experienced different loading stresses, fracturing forces and weathering through the millennia than aggregate from the center of the state, and may be different geologically.

What's the Problem?

Current WisDOT design practices assume that all quarry-sourced aggregate behaves the same, and that all pit-sourced aggregate behaves the same. But the differing histories of sites across the state suggest that differently sourced aggregates may vary in strength.

WisDOT pavement engineers currently determine a pavement material's strength based on its hardness, and use this information to design the thickness of a pavement's component layers. However, AASHTO's new Mechanistic-Empirical Design Guide, which WisDOT will soon adopt, uses a different methodology for pavement design. The guide calculates the thickness of each pavement layer based on resilient modulus, a measure of the elastic properties of a material—its ability to spring back from loading stress.

This method brings to WisDOT pavement designers a more precise, mechanical measure of aggregate strength under loading. A greater understanding of the impact of gradation, source characteristics and regional variation is needed to optimize current and future design practices.

Research Objectives

This study sought to determine if the resilient modulus values of crushed aggregate base course are influenced by material type, source area or geology, or by physical properties such as gradation, angularity and hardness. If correlations proved strong enough, researchers planned to devise a method for predicting the resilient modulus of base course aggregate based on source area, geology and/or physical properties.

Methodology

Investigators divided the quarries into six regions based on bedrock age and characteristics, and divided the sand and gravel pits into three regions based on association with glacial lobes. They obtained samples of WisDOT Gradation No. 2 crushed aggregate base course—the most widely used—from 37 sources within the nine regions. Their tasks included:

- Determining each sample's resilient modulus value with laboratory tests.
- Conducting laboratory tests of gradational impact on resilient modulus with 11 of the 37 samples.
- Reviewing data to determine whether resilient modulus values vary with geology, and whether any physical parameters can be used to predict resilient modulus values.

Results

Research showed that no single or combined set of physical properties identifiable by simple, inexpensive testing could be used to accurately predict resilient modulus values of crushed aggregate base course. Specifically, investigators found:

- Resilient modulus values did not differ between pit and quarry groups, contradicting the WisDOT

Investigator

"We did not find a correlation between resilient modulus values and physical properties of aggregate such as grain size and angularity."

–Paul Eggen
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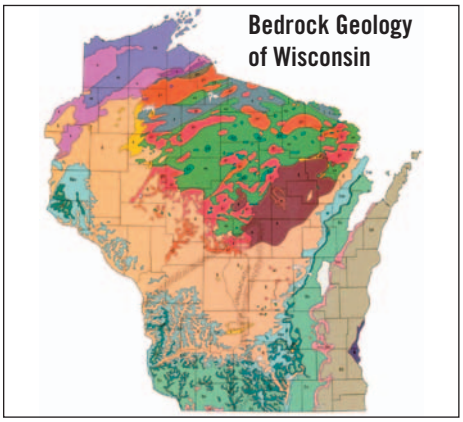

The geologic history of Wisconsin aggregate impacts its strength; limestones and dolomites from quarries in the eastern, western and southern regions of the state proved stronger than granites from quarries in the central areas (page 1 of the Map Appendix of the final report).

design assumption that quarry-sourced aggregate is stronger than pit-sourced.

• Within broadly categorized quarry groups, resilient modulus values varied significantly between the stronger limestones and dolomites (carbonates) from quarries in the eastern, western and southern regions of the state, and the weaker granites from quarries in the central areas of the state. Variation within these regions was insignificant.

• Variation in resilient modulus values among sand and gravel pits was not significant.

• The age of the stone in a carbonate quarry did not impact resilient modulus values, nor did the type of parent material in a pit. Other physical characteristics influenced resilient modulus values in most geologic subsets, but not in a sufficiently predictable manner.

• Varying gradation within an aggregate source resulted in changes in resilient modulus, but these changes were not consistently large or predictable.

Implementation and Benefits

This study provides a solid base of information WisDOT can use in implementing the new AASHTO design guide, as well as more precise data about the performance capability of the state's aggregate sources. With more research, current design practices in Wisconsin may be refined, which will further prepare WisDOT to accurately adapt new mechanistic design procedures to the state's aggregate sources. This research also affirms that Wisconsin's predominant base course aggregate material, limestone, has greater resilient strength than harder granite material.

Further Research

Investigators believe further research will broaden our knowledge of the impact of gradation and source site characteristics on crushed aggregate. They recommend obtaining resilient modulus values from additional aggregate sources, which may allow stronger conclusions to be drawn regarding the effects of geologic factors and physical properties.

Researchers also recommend further analysis of the impact of resilient modulus variation on base course layer thickness. If the effects are significant, they propose that WisDOT create a database of the resilient modulus values of all its crushed aggregate sources. This would aid designers in determining the optimal thickness of the base course layer for individual paving projects.

This brief summarizes Project 0092-02-01, "Determination of Influences on Support Strength of Crushed Aggregate Base Course Due to Gradational, Regional, and Source Variations," produced through the Wisconsin Highway Research Program for the Wisconsin Department of Transportation Research, Development & Technology Transfer Program, 4802 Sheboygan Ave., Madison, WI 53707.

Nina McLawhorn, Research Administrator

Project Manager

"This study gives us more confidence in our aggregates; the limestones and dolomites seem to perform better than the granites."

–Dan Reid
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